Analytics for Demand Response Optimization in a Microgrid

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Demand Response – What and Why

Demand Response (DR): Adjustment of electricity consumption during peak load periods in response to a signal from the utility.

Our Research Focus
- Develop reliable forecasting models for consumption and curtailment to assist campus facility managers
- Design Policy Engine for DR optimization on campus
- Map results from campus experiments to city-scale

Benefits of Analytics for Utility
- Reliably forecast electricity demand
- Plan generation and supply
- Implement DR programs
- Decide time-of-use pricing
- Determine baselines for curtailment

Benefits of Analytics for Customers
- Interpret historical electricity consumption
- Adjust consumption according to forecasts
- Adopt energy-efficient practices
- Schedule on-site generation
- Effectively participate in DR programs

Data-driven Analytics

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Source</th>
<th>Features</th>
<th>Relevance for DR</th>
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</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>FMS</td>
<td>15-min; all buildings</td>
<td>Build forecasting models of consumption</td>
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<td>Customer</td>
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<td>Non-temporal; select group</td>
<td>Model customer participation in DR</td>
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<td>Behavior data</td>
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<tr>
<td>Weather data*</td>
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<td>hourly; temp. and humidity</td>
<td>Affects consumption &amp; curtailment</td>
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<td>Static</td>
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*publicly available

Goal: provide decision support for DR:
- the buildings for load curtailment
- the subset of customers to target for voluntary curtailment signals
- the set of strategies for individual buildings and customers

Challenges:
- Balance curtailment and comfort levels
- Adjust to changing customer preference
- Some buildings have manager override

Current DR Policies:
- Ad-hoc or heuristics-based
- Address static and short term optimization

Goal: Determine the following:
- Voluntary curtailment signals
- Design, develop, and field ML models that work reliably for following granularities:
  - Temporal: 15-min and Daily
  - Spatial: Building-level and Campus-level

Method:
- Provide decision support for DR: Temporal: 15-min and Daily
  - Spatial: Building-level and Campus-level

Demographic Analysis

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Consumption Modeling

Goal: Design, develop, and field ML models that work reliably for following granularities:
- Temporal: 15-min and Daily
- Spatial: Building-level and Campus-level

Modeling Method
- Time-Series Model (Holt-Winters & ARIMA): Uses previous time series energy use-values to predict future values
- Regression Tree Model: Maps a variety of direct and indirect features, $X_i$ to the output, $Y_i$.
- Our proposed method: Causality-driven Hybrid Model

Pros & Cons
- Domain knowledge not required
- Addresses variable trends/seasonality
- Requires model parameter estimation
- Time-invariant model
- Easy to interpret from domain perspective
- Making predictions is fast
- Prediction possible with missing data

Curtailment Modeling

Goal: Determine the following:
- Depth of curtailment (how much can be reduced)
- Latency of curtailment (how long can it sustain)
- Duration of curtailment (how long can it sustain)

Modeling approach
- Supervised learning (ongoing work)

References


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